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ABSTRACT

Developing countries have struggled with low electrification rates in the rural areas. This study investigates one major issue impeding the rural electrification programmes in rural Kenya: high connection payments. The paper uses estimates obtained from a stated preference study, namely a contingent valuation method completed in 2007, to examine the willingness to pay to connect to grid-electricity and photovoltaic services. Expanding rural electrification will need subsidies, but the study shows that some forms of subsidy are more effective than others. The key findings suggest that the government needs to reform the energy subsidies, increase market ownership and performance of private suppliers, establish financial schemes and create markets that vary according to social-economic and demographic groups.

Key Words: Sub-Saharan Africa, willingness to pay (WTP), affordability, energy, rural electrification

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1. INTRODUCTION

The electricity market involves a complex system where: economic, technical, institutional, financial, social, political and environmental factors influence the demands of the different consumers. Amongst all these factors, the institutions for the delivery of electricity services and the provision of finance to customers greatly affect these markets. In this context, policy refers to any new laws or regulations that: promote, accelerate or improve electricity services among rural populations. When a government policy seeks to promote access to renewable energy sources, it needs to influence factors such as: affordability, disposable income, availability and high quality of modern sources. (Barnes *et al.* 2005). In the case of the residential sector, affordability is particularly considered to be one of the main obstacles to the adoption of modern energy. This paper explores the affordability, access and investment regarding electricity services, by estimating the subsidies required and the policy actions needed to increase the take up of rural electrification programmes (REP) in Kenya.

Like most countries in sub-Saharan Africa (SSA), Kenya is not an exception in facing energy dilemmas – one of the key obstacles to the shift to modern energy consumption is the limited access to electricity for households, particularly in the rural areas. The overall electrification rates in SSA (2000) stand at 23%, with the urban and rural area figures standing at 51% and 8% respectively (International Energy Agency (IEA) 2002). However, Kenya has electrification rates below the SSA average with 14% overall connection and a breakdown of 42% and 4% for urban and rural areas respectively (Kenya National Bureau of Statistics (KNBS) 2000). One reason for this low level of electrification in rural areas is the lack of available finance to cover capital and operating costs for generation, transmission and distribution of electricity, which are higher than in urban areas. Moreover, the high connection costs coupled with low consumption of electricity and low incomes among rural households are further obstacles to the electrification of these households.

Most rural households consume traditional energy sources derived from wood fuel, charcoal, agricultural residues and cow dung. In fact, the dominant energy source for non-electrified households in Kenya is primarily wood fuel and charcoal. Wood fuel provides 70% of the energy for all sectors in the country, except for the transport and commercial sector. Its use is common among households in rural areas, because it is relatively cheap and widely available and in fact 80% of these households consume this type of fuel. The impact of these traditional fuels on rural households includes adverse effects, such as: indoor air pollution (IAP), poor lighting and deteriorating environmental and economic well-being. It has been reported that households are willing and able to pay, on average, about US$3-US$10 per kWh for improved energy services based on renewable energy resources including biomass (Kammen and Kirubi 2008). Given such a high willingness to pay (WTP), one of the paradoxes is why electricity suppliers are not forthcoming and this paper attempts to provide some answers to this.

There have been various policy programmes set up by the government and other relevant institutions, such as the Kenya Power & Lighting Company (KPLC), to increase rural electrification. One of the major areas has been the rural electrification programme (REP) established in the early 1970’s. The REP funds are obtained from a 5% levy, namely the rural electrification programme levy fund (REPLF), which is charged to all electricity users nationwide. The REPLF is one of seven decentralized operational funds in Kenya aimed at alleviating socio-economic disparities at the local level.

Another initiative promoting electricity access in the rural areas is "*Umeme Pamoja*", which translates as "Electricity Together". This campaign aims to establish a joint group of households, so as to connect them collectively to the grid, thus saving costs. This scheme is financed by the group settlement electrification schemes created by the KPLC. According to them, this scheme is aimed at making electricity connection easier, affordable and faster (KPLC 2006).

In Kenya the REP cost has been estimated to be between US¢ 30 to US¢ 40 per kWh, compared with an amortized life-cycle cost of US$ 1 to US$ 2 per kWh for solar and battery operated systems (Jacobson 2005). According to the World Bank (1995), only 10 to 50% of the economic cost of REPs is recovered from the users; thus these programmes have to be heavily subsidised by urban industrial users or by the government. About 60% of the REPLF finances new grid-extensions, with the rest being spent on operation and maintenance (Aligula *et al.* 2006). Furthermore, Kenya's REP has been handicapped by financial burdens (Kenya Integrated Household Budget Survey (KIHBS 2007). According to Eberhard and Gratwick (2005) the greatest challenge for energy market in Kenya is the sustainable balance between investment and supply. Indeed, investment through greater involvement of new providers including the private sector is arduous task. In the case of Kenya, privatization of the electricity sector is still embryonic and more has to be done to improve the reform efforts.

This paper is structured into five sections. First, section 1 has provided an introduction and section 2 reviews current fuel use among rural households and the subsidies and affordability structures in place, as in the case for Kisumu district in Kenya. This is followed by a review of the valuation estimates for grid and photovoltaic systems (section 3), where results from a contingent study are used to review the tariff design in order to meet the costs of electricity connection. Recommendations are put forward with regards to increase of access and affordability of electricity service in rural areas (section 4). Section 5 contains the conclusion.

2. CURRENT FUEL USE, SUBSIDIES AND AFFORDABILITY

Rural households, not only have limited access to modern energy sources at reasonable rates, but also incur high expenditures on traditional fuel sources and this exacerbates the inaffordability of household fuels. Following Kebede’s (2006) estimation on the impact of energy subsidies on Ethiopian households, *Table 1* shows the mean monthly fuel consumption for electrified and non-electrified rural households used in a Kisumu sample, converted into gross energy use in mega joules (MJ). This fuel consumption calculation involves the conversion all fuel sources for both rural electrified and non-electrified households.

Table 1: Mean monthly fuel consumption for electrified and non-electrified rural households

			Electrified				Non-electrified			
		Energy content (MJ per unit)	Quantity	Price	Expenditure (Ksh)	Gross energy use (MJ)	Quantity	Price	Expenditure (Ksh)	Gross energy use (MJ)
Agriculture Residue	Kg	1.6	2.37	0.00	0.00	3.79	7.59	0.00	0.00	12.14
Dung Cakes	Kg	1.7	0.00	0.00	0.00	0.00	6.00	0.00	0.00	10.20
Firewood	Kg	2.4	32.09	14.04	450.35	77.01	35.79	10.94	391.55	85.89
Charcoal	Kg	9	18.17	81.31	1,477.56	163.54	29.57	48.79	1,442.59	266.09
LPG	Kg	27.3	19.25	47.72	918.49	525.42	0.00	0.00	0.00	0.00
Kerosene	Litres	15.1	52.61	5.65	297.17	794.36	81.64	4.32	352.81	1232.77
Electricity	kWh	3.6	59.09	4.19	247.73	212.73	0.00	0.00	0.00	0.00
Candles	Klumen	0.2	6.94	6.27	43.48	1.39	13.00	3.46	45.00	2.60
Total energy expenses	(Ksh)				3,435	1,778			2,232	1,610
Total household expenses	(Ksh)				18,037				10,755	
Share of total energy to total expenditure					19%				21%	

Source: Survey 2007

As indicated in *Table 1*, electrified households are better off with respect to energy than those non-electrified, in that the proportion of expenditure on total energy use for the former is 19%, as compared with 21% for the latter. However, according to Fankhauser and Tepic (2005) a rule of thumb that should be achieved as the budget limit for energy services is 10% of total expenditure or income. Thus, it can be seen that the energy expenditure proportion for both electrified and non-electrified households in this instance is above this rule of thumb figure. Whilst electrified households spend a lower share of their total expenditure on energy, their total expenditure is almost 54% higher than non-electrified households and their energy consumption is 10% higher in megajoules, indicating that electrification is a move to more expensive energy. Given that their total expenditure levels are 67% higher than non-electrified households, one can also conclude that the latter are generally much poorer than the former.

We should also note from *Table 1* that electrified households use a lot of LPG, whereas non-electrified households report no use of this fuel. It would appear, therefore, that being electrified is associated with a shift to a cleaner fuel which has significant health benefits. Lastly, it is interesting to observe the difference in fuel prices between the two groups. In this regard, the price for the three main fuels, namely: firewood, charcoal and kerosene, are higher among the electrified households than for the non-electrified households. This needs further investigation, but it could reflect the (a) purchase of better quality fuels by the richer electrified households or (b) the fact that poor households are willing to go further to search for lower cost sources, or both.

For both electrified and non-electrified households, the three fuel sources: firewood, charcoal and kerosene represent a major proportion of their usage. However, in comparative terms these three fuel sources take up 98% of the non-electrified total energy expenses, whereas the figure is 65% for their electrified counterparts. This means that the non-electrified households are spending considerably more on these traditional fuels than electrified households. One way of reducing the consumption of these fuels by the non-electrified is to provide them with electricity. However, if the non-electrified households are to make such an energy usage shift, this means they would reduce consumption of cheaper fuels, such as: kerosene, firewood and charcoal and thus they would require electricity subsidies, so as to keep their energy expense levels the same.

One measure of the affordability of electricity to the rural non-connected households would be to ask how could they afford to buy electricity and still maintain their present energy consumption levels. For example, to do so they could reduce their consumption of firewood, kerosene and candles to release some money for electricity. *Table 2* shows the amounts of energy and pattern of expenditure under one such arrangement where the price of electricity is estimated to be Ksh. 4.19 per kWh.

Table 2: Potential for Electrification for Non-electrified Households
(Assuming no increase in expenditure on energy and same total energy provision)

		Energy Content	Non-Electrified			
		MJ/Unit	Quantity	Price	Expenditure	Energy
Agriculture Residue	Kg	1.6	7.59	0.00	0.00	12.14
Dung Cakes	Kg	1.7	6.00	0.00	0.00	10.20
Firewood	Kg	2.4	32.09	10.94	351.06	77.02
Charcoal	Kg	9.0	29.57	48.79	1442.72	266.13
LPG	Kg	27.3	0.00	47.72	0.00	0.00
Kerosene	Litres	15.1	76.40	4.32	330.05	1153.64
Electricity	kWh	3.6	25	4.19	104.75	90.00
Candles	Klumen	0.2	6.94	3.46	24.01	1.39
Total Energy Expenditure	Ksh				2,253	1,611
Total Household Expenditure	Ksh				10,755	
Energy Exp. As share of Total	%				21%	

Source: Survey 2007

Moreover, in this particular example it is taken that households can afford to buy about 25kWh at this price, which excludes connection and fixed charges. That is, if a household is not connected, there are significant connection charges, which along with other fixed charges, raise the cost per kWh well above this figure of 4.19 Ksh/kWh. In respect of this, currently there is a fixed consumption charge of Ksh 120 and a fixed connection payment of Ksh 35,000. If that charge is spread over 60 months, at an interest rate of 6.5%, we get a monthly payment of Ksh. 684. Taking this together with the current lifeline tariff of Ksh 2/kWh, we have a cost per kWh of 34 Ksh/kWh (equal to US¢51/kWh). This would increase total expenditure of the non-electrified households from Ksh 2,253 per month to Ksh 2,998 or from 21% of total expenditure to nearly 28%. Clearly, some form of additional subsidy is needed if these households are to be electrified.

As noted above, the charge for connecting non-electrified households under the current arrangement for spreading the cost is around Ksh.684, which represents a capital cost of Ksh 35,000 spread over 60 monthly payments at 6.5% interest. This figure represents less than the household's monthly WTP mean value of Ksh.870 (see *Table 4*) for making a connection. Consequently, it would appear that the non-electrified households could afford an electricity connection, so long as the total energy expenses could be kept within the envelope of current expenditure. As shown in *Table 2,* this may be possible by cutting kerosene and firewood use. However, we have to bear in mind that total energy provided in MJ cannot decline as a result and this acts as a major limiting factor. One possibility is to reduce the monthly payments by spreading them over a longer period or adopting a lower interest rate. Another suggestion would be a lower lifeline rate, but here we have to bear in mind that the current lifeline rate is already low at Ksh. 2 per kWh and is expected to increase in the near future. Moreover, the pressure on the subsidy which currently exists is high, as we will see below. One way of addressing this issue and at the same time making electricity available for new connections, would be to reduce the lifeline rate to cover only 25kWh. This suggestion is investigated in detail later in the paper.

Electricity Subsidies

Electricity serves a heterogeneous population, which includes: industrial, commercial and domestic users and each is serviced under different costs and units of supply. For a variety of reasons, electricity use is cross-subsidized among the various categories and there are subsidy differentials for the different types of users. The KPLC tariff schedules distinguish five classes of tariff rates: A (ordinary domestic consumers and small commercial), B (medium commercial and industrial consumers), C (large consumers and industrial consumers), D (interruptible off-peak supplies to ordinary consumers) and E (street lighting).[1] The commercial and industrial consumers are the major users of electricity for economic production and consume 75.5% of the total of the distributed electricity, whereas the domestic class or residential users consume only 23% (KPLC 2006). The residential group is often considered less important, because of their low consumption rates and low contribution to economic output.

Figure 1 illustrates the various tariff charges for two groups of residential users: non-lifeline tariff (for an assumed consumption of 150 kWh per month) and lifeline tariff (for assumed consumption of 50 kWh per month). It can be seen that in the 1990's and early 2000's both rates were comparable, but more recently the non-lifeline consumption has become much higher compared that of the lifeline tariff for residential households. For those poor households whose consumption is below the lifeline tariff limit, i.e. 50 kWh, their charges have been stable until recently when a new lifeline tariff of Ksh. 2 per kWh (2008) was introduced. Holding inflation constant, the figure shows that the 150 kWh real electricity rate has been continually decreasing since 1999 and it is only recently that the tariffs have risen for all categories of consumers.

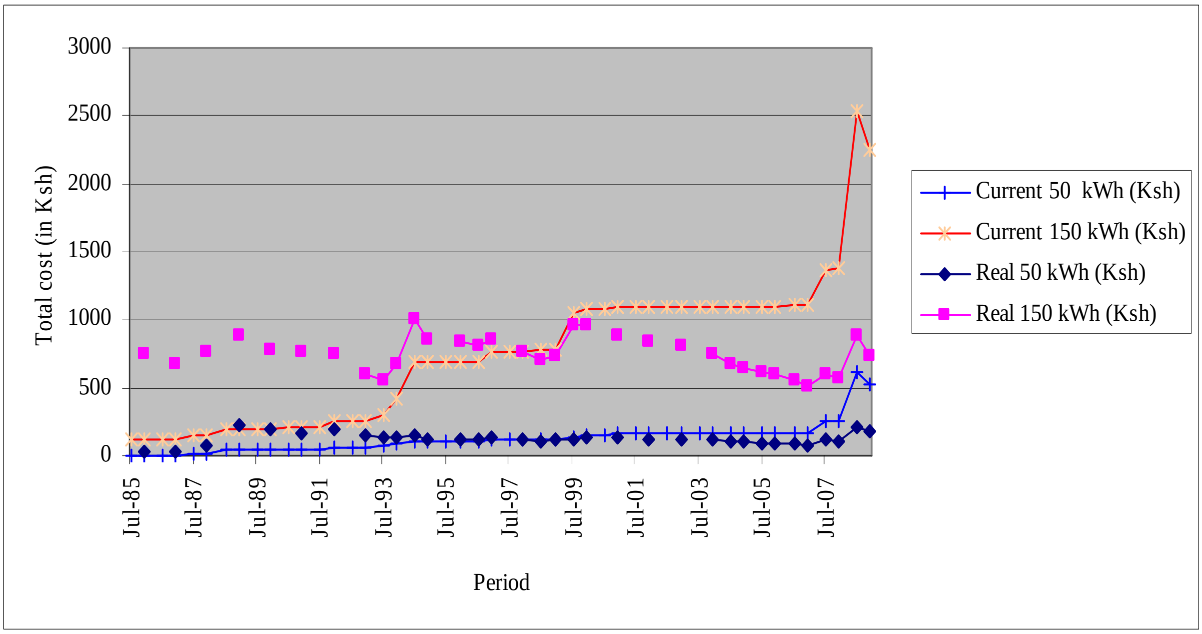

Figure 1: Selected average electricity prices in Kenya for lifeline and non-lifeline residential users (in Ksh./kWh)
Source: Newbery 2005 and own estimation 2008[2]

Other charges above the consumption charges include: fixed charge, Energy Regulatory Commission (ERC) levy, fuel cost adjustment (FCA), foreign exchange rate fluctuation adjustment (FXFA) and VAT. In 2000, the fixed charge was Ksh. 75 (US¢107) and this has now increased by 60% to Ksh. 120 (US¢180) in 2008.[3] The statutory charges including: the ERC levy at Ksh. 0.03 kWh, the REP fee at 5% and VAT at 16% remain unchanged. Other variable costs, which tend to fluctuate with international markets, include FXFA and FCA. Otieno and Awange (2006) reported that as much as 70% of Kenya's electricity consumer bill comprises taxes and levies that are rarely re-invested into the system to improve supply.

New tariff rates introduced in July 2008 by the ERC revised the consumption and fixed monthly rates for all classes. For instance, the domestic monthly charge for the lifeline tariff in 2008 was priced at Ksh. 2.00 (US¢3) per kWh, which is a 50%

increase on the 2000 rate of Ksh. 1.55 (US¢2). Shown in *Table 3* are the old and new tariffs and the estimated subsidies required to cover the long-run marginal cost (LRMC) of Ksh 28.67 and Ksh. 40.28 in 2005 and 2008, respectively.

Table 3: New and old monthly tariff for rural (lifeline) and urban (non-lifeline) users

	Urban	Rural	Urban	Rural
	2005 (old tariff)		2008 (new tariff)	
Quantity (kWh)	74	47	77	50
Marginal cost (Ksh.)[a]	28.67	28.67	40.28	40.28
Tariff (Ksh. per kWh)[b]	5.80	1.55	7.08	2.00
Unit Subsidy (Ksh per kWh)	22.87	27.12	33.20	38.28
Number of electrified population[c]	5,135,332	906,633	5,761,393	1,017,163
Annual (current) subsidy Million. Ksh.	104,291	13,868	176,720	23,362
Annual (current) subsidy Million US$[d]	1,391	185	2,489	329

Notes:
[a] Inflation rate on marginal cost is 12% in 3 years average
[b] Cost excludes: the fixed charge, ERC levy, fuel cost adjustment (FCA), foreign exchange rate fluctuation adjustment (FXFA) and VAT
[c] Electrification rate in rural areas is at 4% and 46% in urban areas (2004/5) taking account the national total population in 2005 and 2008
[d] US $ exchange rate in 2005 and 2008 was 75 Ksh and 71 respectively

According to a Ministry of Energy (MoE) study (2002), a rural household consumes an average of 544 kWh a year, in other words, the monthly average consumption in a rural household is about 45 kWh, whereas urban households use a monthly average of 70 kWh. Taking 5% as the annual increase for both urban and rural users, the estimated monthly quantity consumed in 2005 becomes 74 kWh and 47 kWh respectively and the corresponding figures for 2008 would be 50 kWh and 77 kWh respectively. *Table 3* highlights two important features: the amount of subsidies needed is very substantial, and it can be seen that nearly 90% of the current subsidies are directed towards urban consumers. These figures can be put into perspective by noting that the projected total subsidies of US$2.8 billion in 2008 would constitute about 11% of the GDP totalling nearly US$25billion.

The calculation of LRMC and its use in pricing electricity is to ensure that utility operators are covered in the long-term by the price. There are implications when households are charged below the LRMC as this brings financial difficulties for utility operators unless enormous subsidies are provided by the GoK to cover any potential loss to the suppliers and distributors. For example, the GoK subsidization amount of nearly Ksh. 2.1 billion (US$ 30 million) to the KPLC, between 2003 to July 2006, reduced their wholesale tariff rate from Ksh. 2.36 (US$ 0.03) per kWh to Ksh. 1.76 (US$ 0.01) kWh (Munaita 2008). However, these payouts make the electricity producers dependent on ‘operational subsidies’ and hence they are unprotected when funds are unavailable from central government (Barnes and Foley 2004). For producers and distributors, the affordability and subsidization issues impede cost recovery, particularly when the electricity services are distributed to dispersed households on low-incomes and with low electricity consumption.[4]

3. VALUATION ESTIMATIONS

In 2007 a valuation exercise using a contingent valuation method was carried out to estimate the WTP values for non-electrified households to gain connection to both grid electricity (GE) and photovoltaic (PV) systems in Kisumu district. *Table 4* indicates that the WTP estimates for PV systems have been found to be lower than those for GE, which implies that PV is less attractive than GE. However, this could be attributed to the sample choice, whereby the households who were interviewed were residing less than 600 metres from a transformer and as a consequence, GE connection was seen as desirable and achievable.

Table 4: Average Willingness to pay (WTP) for connecting to grid electricity and photovoltaic systems

	Connection fee amount	
	Ksh.	US$
Grid Electricity (GE) Lump	20,090	301
Grid Electricity (GE) Monthly [a]	870	13
Photovoltaic (PV) Lump	18,560	278
Photovoltaic (PV) Monthly [a]	700	10

[a] Monthly payments are over 5 years

Source: Survey 2007

One of the applications of WTP estimates is to assist in the formulation of effective tariff and subsidy design. With regards to tariff design, the WTP values are the maximum amounts that households can pay for electricity services against affordability. Hence, these values when measured against the full cost of recovery, identify the proportion of the population who can afford provision at their own values. Affordability rates are important for electricity tariff design and also for government subsidy programmes, in recognizing the target population to receive subsidies. If a high proportion of the population is unable to afford the cost of the service and consumption is considered socially desirable, then financial transfers or cross-subsidies are required (Komives *et al.* 2005). It is estimated that about 70% of the households in SSA and India cannot afford to pay the full cost of recovery (Foster and Yepes 2006).

In the next section, the cost of electrifying households against their affordability levels and their WTP estimates are analyzed in detail, with regard to: grid-electricity, solar PV systems and other off-grid systems.

(a) Grid electricity versus solar photovoltaic systems

The WTP for the grid-system, as found in a valuation study, has higher values than those of a solar PV system. One reason for the reduced WTP for solar PV systems among households is the awareness of the limitations of such services, i.e. the restricted duration of provision and knowledge about the benefits of electricity, for other uses apart from lighting and entertainment, which PV systems cannot support. The debate whether to adopt grid-options, as opposed to off-grid options, requires an upfront cost analysis where households' expenses for each electricity service are compared and contrasted. *Table 5* shows the upfront costs for: grid, solar PV and pico-hydro (mini-grid) systems. It can be seen that costs of connecting to the grid are much higher than those for the other options.

Table 5: Upfront cost analysis of grid electricity, solar PV systems & pico-hydro in Kenya

	Grid Electricity [a]	Grid-Electricity 2007 survey [b]	Solar PV system[c]	Solar PV system 2007 survey [d]	Pico-hydro mini-grid serving 65 households (1.1 kW)	Pico-hydro mini-grid serving 110 households (2.2 kW)
Capital cost per household incl. internal wiring & fittings (US$)	2,360-3,840	271	325[c]	200	56[e]	54[e]
Project design & management and labour cost per household (US$)	n.a.	n.a	n.a	n.a	26	17
Subscription/Installation or connection cost per household (US$)[f]	33	534	73	421	80	80
Useful lifespan (years)	Almost infinite	n.a	20[g]	n.a	20	20
Total upfront cost per household (US$)	2,393-3,873	805	398	621	162	151
Total of upfront cost as % of annual household income (non-electrified)	170%	44%	22%	34%	9%	8%

Source: Karikezi *et al.* 2004 and survey 2007

Notes:

a) Estimated cost of grid-extension to one household, where there is no transformer required and the nearest connection point is about 500-900 metres—the equivalent respective distance to the furthest point of connection from the powerhouse for the two pico-hydros considered in Kirinyanga district Maher *et al.*(2003). The cost covers the required: poles, conductors, termination accessories and other fittings

b) Estimated cost of grid-extension within a 600 metres radius of the transformer for one household and associated cost with wires & fittings
c) Cost per solar PV system installed in one household. The system comprises: a 24 W panel, a battery, a charge controller, lights and associated wires & fittings
d) Cost of PV system installed in one household. The system comprises: a 40 Wp panel, a battery, a charge controller, lights and appropriate wires & fittings
e) Total cost of: civil works, generation equipment, control and protection gear and the distribution system
f) Refers to a one-off payment to initiate the electricity service. The amount indicated for pico-hydro is the maximum chargeable fee (for 2 lights and 1 socket). A lower fee of around US$60 is chargeable, where only 1 light and a socket are used. In the case of solar the PV system it is the cost of installing the system.
g) Only applies to PV panel, as battery requires replacement every 3-5 years

Because the cost of both PV and pico-hydro systems are lower compared to grid systems, if the consumer confers value on them equally, it would seem reasonable to promote the two off-grid systems as they are less expensive than the grid systems. This implies that the connection subsidy required for the PV and pico-hydros systems would be lower than for grid electricity. However, the results of this study have revealed it is not that simple because the WTP estimates that have emerged with regards to the value given to PV and grid systems by the households were not the same, that is, households expressed a strong preference for the latter.

(b) Payment options and WTP

There has been progress in reducing the costs for both grid and off-grid services, but the biggest hurdles are the initial connection fees and monthly consumption costs for low-income households (Townsend 2000). In order to assess the affordability for connecting to electricity services, it is necessary to compare household income with connection cost. Affordability refers to the actual ability of a household to pay for goods/services and it can be distinguished between the affordability for access and the affordability for consumption (Estache *et al.* 2002), which are both are examined in this study. *Table 6* illustrates the WTP connection payments as a proportion of monthly income in deciles, for both GE and PV systems, for two payment options: monthly connection and one-off lump sum payments.

Table 6: Proportion of connection payments (monthly and one time) for grid-electricity (GE) and photovoltaic (PV), by income deciles

	One time connection payment				Monthly connection payment spread over 5 years			
	A	B	C	D	A'	B'	C'	D'
Monthly income deciles	GE actual connection cost (onetime)[1]	GE WTP connection estimates (onetime)[2]	PV actual connection cost (onetime)[1]	PV WTP connection estimates (onetime)[2]	GE actual connection cost (monthly)[3]	GE WTP connection estimates (monthly)[2]	PV actual connection cost (monthly)[4]	PV WTP connection estimates (monthly)[2]
1	2093%	657%	1615%	531%	44%	24%	34%	18%
2	1244%	393%	959%	358%	26%	17%	20%	10%
3	1010%	285%	779%	258%	21%	14%	17%	10%
4	844%	274%	651%	257%	18%	13%	14%	10%
5	726%	268%	560%	257%	15%	10%	12%	8%
6	611%	191%	471%	185%	13%	9%	10%	7%
7	499%	123%	385%	123%	11%	7%	8%	5%
8	398%	133%	307%	159%	8%	7%	7%	5%
9	335%	119%	258%	103%	7%	6%	5%	4%
10	184%	103%	142%	73%	4%	3%	3%	2%

Source: Survey 2007
Notes:
1) A one-off lump sum for both grid and PV capital and connection cost is Ksh. 56,350 (US$805) and Ksh.43, 470 (US$621), respectively, obtained from Table 5, which excludes any variable cost
2) Connection at WTP values by income deciles without variable cost, i.e. consumption cost
3) Monthly capital and connection cost excluding variable cost is Ksh. 1,197.27 for 60 months at 10%
4) Monthly capital and connection cost with zero variable cost is Ksh. 923.61 for 60 months at 10%

It is clearly apparent from *Table 6* that the lower deciles would face prohibitive payment levels for one-off payment, regardless of whether they were subsidized or not. Consequently, the preferred payment system is monthly payments, as shown in columns (A', B', C' and D'), but even with monthly payments the WTP is less than the connection cost. Hence, it is apparent that it would be necessary to spread the payments over a much longer period, maybe as much as 10 years, and reduce the interest rate to 5%, so as to increase the take up of electricity connection. To this end, *Table 7* illustrates the monthly connection cost for GE and PV systems for various scenarios based on the figures in columns A' and C' in *Table 6*. That is, with regards to A'', A''', A'''', A''''' represent four different payment periods at 5% for GE at WTP B'. Likewise, for C'', C''', C'''', C''''' are the same extrapolations for PV with WTP D'. It can be seen that wherever the ability to pay is lower than the corresponding WTP, the household in the decile in question can afford connection to either GE or a PV system.

Table 7: Monthly connection costs with varying payment duration at 5% interest

	GE monthly						PV monthly					
	A'	B'	A"	A"'	A""	A""'	C'	D'	C"	C"'	C""	C""'
Monthly income deciles	GE actual connection cost 60 months 10%	GE WTP connection estimates	GE actual connection cost 60 months 5%	GE actual connection cost 80 months 5%	GE actual connection cost 100 months 5%	GE actual connection cost 120 months 5%	PV actual connection cost 60 months 10%	PV WTP connection estimates	PV actual connection cost 60 months 5%	PV actual connection cost 80 months 5%	PV actual connection cost 100 months 5%	PV actual connection cost 120 months 5%
1	44%	24%	39%	30%	25%	22%	34%	18%	30%	24%	20%	17%
2	26%	17%	23%	18%	15%	13%	20%	10%	18%	14%	12%	10%
3	21%	14%	19%	15%	12%	10%	17%	10%	15%	12%	10%	8%
4	18%	13%	16%	12%	10%	9%	14%	10%	12%	10%	8%	7%
5	15%	10%	13%	10%	9%	7%	12%	8%	11%	8%	7%	6%
6	13%	9%	12%	9%	7%	6%	10%	7%	9%	7%	6%	5%
7	11%	7%	10%	8%	6%	5%	8%	5%	7%	6%	5%	4%
8	8%	7%	7%	6%	5%	4%	7%	5%	6%	5%	4%	3%
9	7%	6%	6%	5%	4%	3%	5%	4%	4%	3%	3%	2%
10	4%	3%	4%	3%	2%	2%	3%	2%	3%	2%	2%	1%

Source: Survey 2007

4. POLICY RECOMMENDATIONS

Some of the policy recommendations provided in this section would retain the present government policies. However, recommendations developed in this paper emphasise the need to increase access to electricity services for domestic users. Laid out below are the options that decision makers and policy makers could initiate to meet rural electrification needs. Some of these recommendations have already been proposed by researchers, think-tanks, as well as by government and multilateral institutions. In this paper, whilst we accept many of these proposals, the focus is on the specific needs of Kenya, and through this we have identified a number of idiosyncrasies that could be of relevance to other developing countries. The policies highlighted include: establishing financial schemes, reforming subsidies, creating markets taking into account the SED factors and improving the market ownership and performance of the suppliers.

(a) Establishing financial schemes

Most financial institutions in rural areas cater for salaried rural employees, such as: civil servants, teachers and self-employed proprietors. Therefore, for many first-time users wanting to connect to grid-electricity or PV systems, financial schemes through banks or microfinancing are unavailable. As a result, there is a need to establish long term schemes to finance initial or upfront costs for acquiring PV systems and grid-electricity, which as mentioned earlier are an impediment to electrification in rural areas. In this regard, the financial programmes available for connecting households to electricity services vary according to the different financial institutions' interests. For example, in Kenya the financial schemes provided by the banks and micro-finance institutions for connecting to solar PV systems are far better than those for grid-electricity, as monthly instalments by banking loans or hire purchase systems exist for the former owing to shorter payment duration and smaller loan amounts. According to World Bank surveys in a number of countries, respondents have indicated their willingness to take medium-term loans to pay the upfront cost, which they would then pay back through their monthly bills over five years or more (Townsend 2000). A good example is the case of Bolivia, where the number of new customers doubled when connection cost was spread over 5 years, despite an increase from 25 to 30 cents per kWh in grid-electricity cost (Barnes and Foley 2004). This is unlike Malawi's case, where new customers were charged upfront full cost line extension, (with a 30 year life), which resulted in 2% rural electrification rates.

The results of this study have shown that there is a high WTP for GE electricity even for individuals in poor households, regardless of it costing a substantial share of their income. However, households' WTP for PV systems has emerged as being lower than for grid electricity. Moreover, as illustrated in *Table 8*, the difference between the WTP estimates and total cost, by decile, is higher for GE electricity than for PV systems in nearly all cases. That is to say, as the table illustrates, regardless of whether payment is over 60 months (5 years) at 10% interest or over 120 months (10 years) at 5% interest, the margins between the WTP and total cost are higher for grid electricity. In this regard, a negative sign indicates that total cost is higher than the WTP values. For instance, the GE monthly would only be taken up by the top three income deciles at a 5% interest rate and by none of them at a 10% interest rate. Given the low connection costs of PV systems in contrast to GE systems, the PV option would offer a greater potential for market penetration into the non-electrified households, because lower levels of subsidy would be required than for GE.

Table 8: Difference between grid electricity (GE) and photovoltaic (PV) system costs and WTP values, by deciles, monthly payments and interest rates (in Ksh.)

	GE monthly		PV monthly	
WTP values by decile	Difference between total cost and WTP values, 60 months, 10%[1]	Difference between total cost and WTP values, 120 Months, 5%[1]	Difference between total cost and WTP values, 60 months, 10%[2]	Difference between total cost and WTP values, 120 Months, 5%[2]
1	-863.77	-264.18	-438.61	23.93
2	-726.77	-127.18	-454.36	8.18
3	-717.06	-117.47	-391.32	71.22
4	-632.27	-32.68	-282.67	179.87
5	-742.02	-142.43	-294.11	168.43
6	-651.07	-51.48	-259.41	203.13
7	-699.94	-100.35	-334.61	127.93
8	-453.57	146.02	-267.30	195.24
9	-500.05	99.54	-245.83	216.71
10	-586.48	13.11	-287.03	175.51

Source: survey 2007
Notes:
1. Monthly total market cost inclusive of variable cost for a monthly consumption of 50 kWh costing Ksh.300. For a GE system the total monthly cost is Ksh. 1,497.27 for 60 months at 10% interest and it is Ksh. 897.68 for 120 months at 5% interest.
2. Monthly total market cost for a PV system for 60 months at 10% interest is Ksh. 923.61 with zero variable cost, whereas for 120 months at 5% interest it is Ksh. 461.07.

(b) Reforming electricity subsidies

Creating subsidy policies needs to take the form of a delicate balancing act. Subsidies must be made available to give the poor access to modern energy services, however, care must be taken not to distort the energy market or target one type of fuel more than another. Moreover, it is important to ensure that the better-off do not benefit from the subsidy arrangements at the cost of the poor. There have been criticisms about the role and allocation of subsidies by governments in the markets and the main objection is that they should not be earmarked towards operating costs. CORE International Inc. (2003), an international consulting firm supporting international development agencies, amongst others, has posited that subsidization of investment costs or capital costs rather than consumption is more effective. Moreover, it has been argued that operating costs should be wholly-financed by the tariff charges. A good example is that of the Argentinean subsidies provided towards connection, where households paid 10% of the initial installation or connection cost of U$800 and 40% of the system life-cycle costs (US$1,400 including maintenance and battery costs), over the 15-year life of the system and the remaining 50% of the life-cycle costs were covered by government subsidies (ESMAP 2000a). The connection cost, in the case of Argentina, was partially subsidized by a World Bank loan, GEF grant and there was some funding by the state (Tomkins 2001).

On the utility providers' side, the amounts of subsidies which can be made available to them are determined by the scale of electrification that they are able to offer. According to Tomkins, output based contracting where private providers are given subsidies towards output, is one way forward for meeting the electrification needs of rural areas (2001). This approach has been applied in the case of Argentina, where exclusive concession areas have been established and the private operator is paid a connection subsidy that is related to the distance from the grid. Similar to this was the case of Chile, where the state identified areas needing electricity and through a special fund provided a one time direct subsidy to private electricity distributors to cover some of the investment costs involved in their rural electrification project and this resulted in an increased coverage of rural electricity systems, from 53% in 1992 to 76%, by the end of 1999 (Jadresic 2000).

In the past the GoK has subsidized off-grid options, such as solar PV systems, by removing import duties on PV components. In this regard, initially, the imported components were subject to an import charge of 30% duty, which raised the costs of the systems (Barnes and Floor 1996). However, the elimination of this charge has been insufficient to advance the adoption of these alternatives fast enough. One way to accelerate the connection of these systems is to set up effective financial structures. This, as discussed earlier, would involve the establishment of financial schemes by the government in collaboration with the financial institutions, such as local banks and microfinancing companies, to identify and provide unsecured credit for the poor. However, careful attention will need to be paid to the detail regarding how to deal with defaults, where customers end up not paying the monthly payments. Indeed, delinquent consumers are difficult to manage and require high administrative costs to monitor. Ledgerwood (1999) has suggested that once defaulters have been identified, field staff should follow up arrears payments. If this fails to work, some of the following initiatives should be employed: public announcements in the press as to who is a delinquent payer, repossession of assets, erecting of signage outside the borrower's home and/or charging a defaulter with a crime.

(c) Subsidizing consumption costs and connection

Subsidies should be aimed at creating efficiency and equity. On the one hand, charging more to those who are wealthier or big users is appropriate, but on the other hand, these categories may gain the incentive to leave the system and self-generate, owing to the high costs imposed on them. The GoK, along with the ERC, need to develop a system that can identify the target group for subsidized connection and lifeline tariff, i.e. the poor, which is difficult. Typically, around 35-40 kWh is the basic monthly consumption for low-income households in urban areas (Barnes and Floor 1996). These consumption figures, however, are similar to those for high-income rural households in Kenya today, (it should be acknowledged that they are a decade old) and this makes any cross-subsidization arrangements, whereby the richer households help to subsidize the poor, almost impossible because they cannot be differentiated. One proposition is to reduce the lifeline tariff to 25 kWh, or less, for low-income households in rural areas who only use small amounts of electricity for lighting purposes. In this vein, other developing countries, such as Thailand, have set their lifeline tariff at 35 kWh per month.

Another proposition here is to subsidize the connection costs for both GE and PV systems, that is to say, the GoK through the local authorities, could subsidize a third of the connection cost with the rest being paid by the household. However, this connection subsidy would not cover the wiring and consumption costs, for which end-users are responsible. As shown in *Table 9,* without subsidy only the highest two income deciles can afford GE systems, if we accept the 10% rule of thumb as discussed previously. This figure rises to the four highest deciles when considering a non-subsidized PV system. However, when a subsidy of a third is included, the proportion of GE households coming within the 10% affordability benchmark rises to four deciles and perhaps more importantly, regarding PV systems, seven deciles fall within this range. This indicates that subsidizing PV would be a far more effective way of meeting the REP objectives in Kenya.

Table 9: Comparison of monthly charges for connection at actual and subsidized payment cost for grid electricity (GE) and photovoltaic (PV) systems as % of Income

Monthly income deciles	GE actual connection cost (monthly) inclusive of 50 kWh use charge[1]	PV actual connection cost (monthly)[2]	GE subsidized-connection cost 1/3 off inclusive of 50 kWh consumption charge (monthly)	PV subsidized-connection cost 1/3 off, (monthly)
1	58%	39%	43%	26%
2	34%	23%	26%	15%
3	28%	19%	21%	12%
4	23%	16%	17%	10%
5	20%	13%	15%	9%
6	17%	11%	13%	8%
7	14%	9%	10%	6%
8	11%	7%	8%	5%
9	9%	6%	7%	4%
10	5%	3%	4%	2%

Source: Survey 2007

Notes:

1) *Monthly total market cost of GE system inclusive of variable cost of 50 kWh costing Ksh.300 is Ksh. 1,599.33 for 60 months at 10% interest*
2) *Monthly total market cost for a PV system for 60 months at 10% interest is Ksh. 1,041.11 with zero variable cost*

In other developing countries the subsidization policies vary according to governments objectives, with regard to REP targets. For example, in the case of Chile where rural electrification stands at around 80%, the average state subsidy per household was US$1,080 in 1995, which was later increased to US$1,510 in 1999, owing to the priorities set by the state for maximizing rural electricity coverage (Jadresic 2000). However, there been other cases where subsidies have disproportionally been allocated, such as in case of Malawi, where the urban households have been subsidized at US$ 300 compared to rural households getting US$ 60. In the case of Kenya, there needs to be a distinction made between several different regions, where the Coastal, Western and Eastern provinces are perceived as being poorer and as having certain climatic and geographic conditions which affect the cost of supply from both grid and off-grid systems. That is, there needs to be a sliding scale of subsidies with regards to cross-subsidizing for the different Kenyan regions.

(d) Creating markets according to SED groups

According to De Gouvello and Durix (2008), there are two approaches, namely systematic and pragmatic, which can been used to address the impact of an REP. Both approaches are complementary, with the former providing an overview of all the productive uses of electricity to potential users, whereas the latter identifies practical cases of existing energy programmes, thus offering tangible results. The importance of combining these two strategies is to be able to assess the extent to which REPs influence the socio-economic development of communities. Moreover, the two approaches, in combined form, can assist in the identification of appropriate cottage industries for rural households who intend to start income generation businesses, particularly those related to the agricultural sector. Income generation and ownership for small rural businesses leads to a sense of achievement and well-being, which stimulates further economic development. These activities can mushroom, involving many participants, and thereby lead to significant regional/district economic growth. They also generate income, which makes electricity connection affordable.

Where grid-electricity is expensive for rural households, because of high costs and dispersion of the population, the penetration of other off-grid systems, such as PVs, should be encouraged. As found in this study, the differences between WTP and cost for PV systems are generally much lower than for GE (see *Table 8*). Hence, subsidies should be targeted at PV system provision, rather than for the grid, by directing them towards those private PV system distributors who would be willing and able to facilitate the connection of dispersed households.

Additionally, there is a potential market for the electrical equipment and appliances that people need to gain access to. In this vein, the households interviewed in our survey were found to own: radios, televisions and electric irons. That is, as electricity end-use patterns change consumers invest more in household appliances to improve their levels of comfort and entertainment. With mass produced televisions, CD and DVD players and radios from countries such as China and India, the prices of these devices have declined over time and this has led their penetration into the rural areas of developing countries. However, in line with a responsible demand-side management approach, i.e. sustainability with regards to energy consumption, the GoK needs to ensure that the energy efficiency of such goods is closely monitored, by clear labelling showing the efficiency ratings of such products.

(e) Increasing market ownership and performance of private suppliers

Market ownership for grid-electricity lies with the KPLC, which controls both the transmission and distribution sides. This model is a one distributor approach and it could be modified to accommodate private sector participation and ownership. Kenya has a number of well established independent power producers (IPPs); however, the transmission and distribution is not privatized, as the KPLC is partially state owned. If privatization were allowed, then there would be alternative options for transmission and distribution.

On the one hand, charging full cost to customers is beneficial, but on the other, these charges can be too high for consumers to afford, hence creating an incentive for self-generation. Analyzing international private participation in power projects, an ESMAP paper reported that nearly 70% of private participation in developing countries was concerned with generation activities, whereas electricity transmission stood at only 3% and distribution at 14%. This would suggest potential investors perceive the latter two areas of operation as carrying significant market and commercial risks (Covindassamy *et al.* 2005). Nevertheless, the government has an important role in maintaining competition in the market for both on-and-off grid, by ensuring that rates are competitive. In other words, their role is to ensure that electricity prices are on a level playing field.

One suggestion emerging from this study is that there is a need for an alternative model for addressing the REP objectives, by offering both grid-and off-grid options and not simply concentrating on the former. We propose that part of Kenya's REP strategy could take the form of the setting up of a rural energy service company (RESCO) to provide electricity for households, as well as the community. Households would then contract a RESCO for either grid or off-grid electricity services and for maintenance and repair of equipment owned by the company. Alternatively, the equipment could become the property of the household after a specified payment period. A good example of this system can be found in India, where local electricity retailers, like the independent rural power producers (IRPP), own small businesses or cooperatives and they secure credit financing to establish an off-grid system or mini-grid. The latter is achieved by either creating a new distribution system or leasing a sub-station already in existence (ESMAP 2000b).

Another effective approach has been one in Sri Lanka, where the World Bank/GEF Energy Services and the national utilities established “non-negotiable” power-purchase tariffs and contracts (PPAs) with third-party mini-hydro developers (Miller and Martinot 2001). The introduction of these IPPs and PPAs, along with concessions, has accelerated the privatization of the markets. In Kenya, various PPAs have been established with the IPPs, but what appears to have played an important role in securing these deals is the involvement of multilateral organizations, that bring credibility to the projects (Eberhard and Gratwick 2005).

The Kenyan market for PV systems is completely privately owned and the suppliers are actively engaged in connecting and distributing solar PV services, on a cash basis. According to GTZ Eastern Africa Resource Base (2006), it was estimated that the PV module sales figure was around 25,000 to 30,000 annually and approximately 200,000 rural households owned solar systems. Conversely, the average annual connection of new REP users was 100,000 and the total numbers of rural electrified households was 180,000 at this time (KPLC 2005/6). What we suggest in this study is that there is a need to step up to a fee-for-service model, like that of Zambia, where energy service companies (ESCOs) provide households with PV services on a fee basis. Adopting a fee-for-service plan allows for a monthly fee to be charged and in return off-grid services are provided. With an ESCO there is a ‘market-oriented approach’ to marketing a PV system as a ‘service package’, rather than one of ‘functional hardware’ (Gustavsson and Ellegard 2004). Van der Vleuten *et al.* (2007) have put forward two institutional models for PV markets. One is the involvement of an ESCO or third party dealer in receiving concessions through a government agency to finance the PV systems to users, whereas the other, after Nieuwenhout *et al.* (2000), is fee-for-service through a third energy party (or ESCO). [5] The latter model i.e. the fee-for-service, is recommended by us because as Varho (2002) pointed out, such ESCO rental systems involve close collaboration with communities and consequently it is easier to reduce payment default levels. Moreover, over time the ESCO provider of PV systems can transfer the ownership of the system after all payments have been completed by the households. In addition, the ESCO's ownership and maintenance of the solar systems can ensure that they continue to function, so long as households pay the usage fee (Kaufman *et al.* 2000). The disadvantage of this method is that it requires business management and technical know-how to operate and hence be viable in the long run, a feature which tends to be lacking in rural areas (Cabraal *et al.* 1996).

5. CONCLUSION

The benefits of electricity services cover both indirect and direct gains. The data presented in this study has shown that these quantifiable benefits, obtained from WTP estimations, weighed against the subsidies received by users and the costs incurred in electricity generation and distribution by suppliers, can allow for the calculation of the welfare benefits of electrification (*Table 8)*. Moreover, electricity benefits are not only experienced by current users, but also potential users. Hence, policies should be in place, not only to improve existing electricity services, but also to connect those who are non-electrified. The paper has discussed the constraints on extending electricity in this way and has made some proposals for overcoming these.

The roles of the different service providers, namely the: public, private and community-based agencies that are needed for electrifying households should function in a complementary way and this would create healthy competition among all the protagonists (Barnes and Floor 1996). Moreover, the Kenyan policy makers as well as the producers and distributors should take the opportunity to learn from other developing or emerging markets' REP models, to guide them in revamping their current programme. The government position, in providing long-term subsidies for operating and maintenance costs to entities, should be diverted to focusing on providing; one-off subsidies to private investors and equity financing or long-term loans to intermediaries, in order to help in the financing of rural electrification. At the consumption level, it is recommended is that the subsidies are re-directed to benefit the poor by helping them to get electricity and by lowering the lifeline tariff consumption unit for poor households to 25 kWh or less. As explained above, this group consumes such small amounts of electricity and as a result they would be the main benefactors of such a change. Two options that are available to allow for the fulfilment of this recommendation are: firstly, charging the lifeline tariff to only those who consume less than 25 kWh and secondly, charging the lifeline tariff to everybody for the first 25 kWh consumed and thereafter charging a higher price. The former is the fairer option, however, it is politically difficult and discourages consumption for poor households who would like to consume above 25 kWh. That is, under these circumstances there can be a social trap where some poor households are subsidized at a lower rate than others, but are deterred from increasing their energy consumption. We suggest there should be a better integrated assessment of electricity subsidies in Kenya, as well as in other developing countries, that can help to identify the winners and losers in the different social groups in relation to energy subsidy reforms.

The case studies presented in this study have been aimed at highlighting some of the best practices and principles that could be adopted to meet the challenges of the REP in Kenya. From this best practice and the empirical analysis, we argue that there is a need to: identify, target and set tariffs for vulnerable groups, such as the poor and strategically important economic sectors, especially agriculture.

In general, we urge that the perspectives of present electricity users or prospective electricity users, as described in their willingness to pay for different electricity services, should be the driving force behind the shaping of the REP in developing countries, such as Kenya. In other words, the REP should involve a bottom-up approach, where users' needs and preferences determine the electricity policies adopted. In return, policy makers need to formulate regulations that incorporate consumer preferences and to develop, either grid-electricity or decentralized electricity systems, to meet the consumers' needs at affordable prices with plausible payment periods and reasonable interest rates. In conclusion, the government as a facilitator of the REP needs to be more transparent and accountable in its actions, so as to increase the efficacy of the electricity services, to both current users and potential consumers.

6. NOTES

[1] In July 2008 new tariff rates were approved, whereby consumer categories were revised to: domestic, small commercial, commercial/industrial, interruptible and street lighting.

[2] All costs include fixed and consumption charges for each category.

[3] 1 US$ = Ksh. 67 (30 July 2008); source: Central Bank of Kenya, found at http://www.centralbank.go.ke [accessed on 10 September 2008]

[4]Acker and Kammen (1996) reported that for every kilometre of electrification grid extension costs for the KPLC were Ksh 500,000 (US$8,200). Aligula *et al.* (2006) cited that the MoE estimates in 2003 showed that about Ksh. 1.3 million was used to construct one kilometre of an 11 KV or 33 KV line in rural areas.

[5] The difference between these two models is that the former has more conditions prescribed by donor/institutional provider in: terms of coverage, number of users and time period to disseminate the systems.

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